STANDARDIZATION OF PRECIPITATION STATIC TEST METHODS AND EQUIPMENT FOR THE NAVY

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ABSTRACT

The Naval Air Warfare Center Aircraft Division, Patuxent River, is currently the Navy's lead facility for Precipitation Static testing of aircraft. It has been involved extensively with the design and production of standard Precipitation Static test methods and equipment. As part of tasking given by the Naval Air Systems Command, these methods are to be presented to other Navy facilities to provide additional test capability and overall fleet awareness of Precipitation Static. Further, this will provide standard procedures and equipment for Precipitation Static testing of aircraft Navy-wide.

This paper presents an overview of the Precipitation Static test methods and equipment to be standardized, as well as the current plans to distribute these to Navy facilities. Particular attention will be paid to test methodology, design of standard test equipment, and plans for distribution and training.

INTRODUCTION

For over 45 years, the U.S. Navy has been concerned about the effects of Precipitation Static (P-Static) on its aircraft. During this time, however, no effort has been made to produce or distribute standard, acceptable test procedures for ground testing of aircraft. Consequently, to many facilities in the Navy, P-Static testing remains somewhat obscure.

The Naval Air Warfare Center Aircraft Division at Patuxent River has been concerned for some time about the apparent lack of awareness of test techniques on the part of the designers, manufacturers, users, and maintainers of Naval aircraft, despite many published reports and papers on the subject. The Electromagnetic Pulse (EMP) Section of the Electromagnetic Systems Department at Patuxent River has extensively reviewed this material in the hopes that this information can be used to create standard test methods and equipment to be used Navy-wide. The scope of this paper is to discuss the Naval Air Warfare Center's current plans to achieve this goal.

P-Static testing is the responsibility of the EMP Section. Since 1986, all Navy aircraft undergoing electromagnetic environmental effects (E^3) testing at the Naval Air Warfare Center's shielded hangar have been subjected to simulated P-Static testing. Testing of system level components and testing of aircraft at other Navy facilities has also been performed

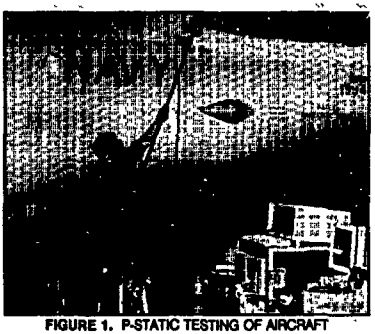

FIGURE 1. P-STATIC TESTING OF AIRCRAFT

The need for other facilities to be able to perform P-Static validation of aircraft during production or maintenance phases is evident. Standard test methods and equipment will give Navy facilities the ability to protect aircraft and systems from P-Static problems. Early detection will preclude the necessity of major test programs to fix P-Static related problems on aircraft. Also, if P-Static testing in the Navy is standardized, all equipment will be interchangeable and it will be relatively simple for any facility to repair or replace damaged or defective parts.

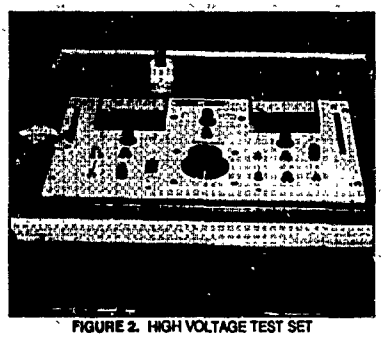

FIGURE 2. HIGH VOLTAGE TEST SET

TEST METHODOLOGY

Currently, ground testing of aircraft at Patuxent River is performed using widely accepted test methods in the electrostatic field. Testing is performed by using a high voltage test set to deposit a charge onto an aircraft with a high voltage ion discharge wand (see figure 1). The wand is comprised of a high voltage dish with electrostatic dischargers attached, which enables the wand to "spray" a simulated P-Static charge onto the aircraft.

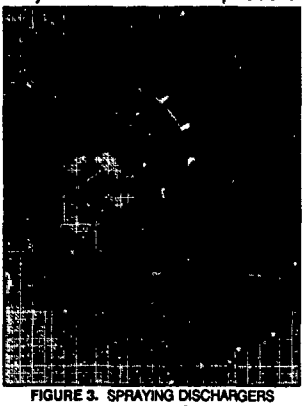

FIGURE 3. SPRAYING DISCHARGERS

Each area of the aircraft is sprayed at 40 kV and approximately 50 $\mu A/ft^2$ current while sensitive hand-held receivers are monitored for any electromagnetic interference (EMI) generated by P-Static. Because the wand is comprised of electrostatic dischargers, P-Static noise generated by the wand itself is almost nonexistent, thus enabling a very effective test method for aircraft. EMI is generally produced due to arcing between isolated sections of the aircraft. However, problems have also occurred due to corona discharge from the aircraft and streamering effects.

FIGURE 4. DLRO MEASUREMENT TECHNIQUES

Noise generated on the receivers can be heard in the form of popping, motorboating or squealing, depending on the severity of the P-Static problem.

After the entire aircraft has been sprayed, the areas with the most serious P-Static problems will be identified. Then the actual aircraft radios or equipment to be tested for P-Static interference can be monitored while each problem area is resprayed at 20 $\mu A/ft^2$ current. This current level has been determined to be severe for inflight P-Static induced on Navy aircraft. However, because the design of the high voltage test set is dynamic (see figure 2), testing can be performed at any voltage level up to 40 kV and any current level up to 200 μA.

This method can be used on a variety of aircraft to determine their susceptibility to P-Static interference inflight. Also, because each problem area can be examined closely, a solution can readily be determined (such as installing a bonding strap).

Testing for P-Static interference is not the only use of the high voltage test set and wand. Additionally, specific checks can be performed on each aircraft static discharger to examine proper discharging capability (see figure 3). A poorly performing discharger will generally begin arcing and generate noise on the hand-held receivers. Also, the wand can be used to find dischargers which may be installed on isolated panels (thereby becoming less effective for dissipation of electrostatic charge from the aircraft). Finally, the wand can be used to test a fix installed on a problem area to ensure that P-Static no longer presents a problem in that area.

During a standard P-Static evaluation, other instrumentation is used to augment testing. A Digital Low Resistance Ohmmeter (DLRO) is used to check bonding of the aircraft (see figures 4 and 5). Bonding checks can be made of installed electrostatic dischargers, fuel tank cap or vent areas (for safety), and also between isolated sections of the aircraft's surface. Bonding checks can be made to determine if the aircraft discharging system functions are in

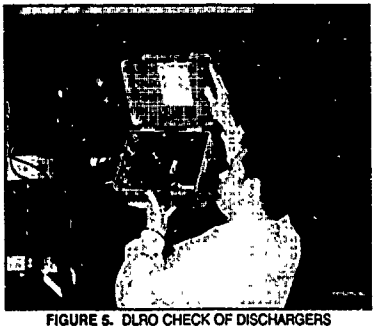

FIGURE 5. DLRO CHECK OF DISCHARGERS

compliance with MIL-B-5087B (1), the

current bonding specification for Naval aircraft.

Also, a digital megohmmeter (megger) can be used to check the tip to base resistance of electrostatic dischargers to be used on aircraft, whether installed or not (see figure 6). This will determine compliance with MIL-D-9129D (2), which gives the current specification limits for Naval aircraft dischargers. This can be used to determine if the discharger has internal damage and may need to be replaced.

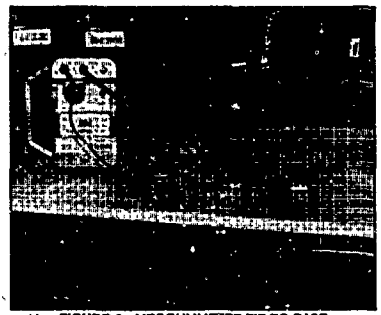

FIGURE 6. MEGOHMMETER TIP TO BASE RESISTANCE MEASUREMENT

All of these test methods are relatively simple to accomplish. However, for the testing to be accomplished correctly and consistently, standard documentation will also be necessary. These will include standard test procedures, detailed operating procedures and equipment maintenance documents. Currently, all three types of documents are available for P-Static testing of aircraft at Patuxent River. However, this documentation can be tailored for global testing at any Naval facility.

If this test methodology can be distributed throughout the Navy for P-Static ground testing of aircraft, a cost-effective, relatively easy standard for P-Static testing can be achieved. Then, other Naval facilities will have the capability and expertise to test aircraft and other systems for problems related to P-Static, without the need for a large test program.

TABLE 1. STANDARD EQUIPMENT LIST

TEST EQUIPMENT:
High Voltage Power Supply
High Voltage Discharge Wand and Cable
Digital Low Resistance Ohmmeter (DLRO)
Digital Megohmmeter (Megger)
Hand-Held Multiband Receivers (2)
Anvil Carrying Cases
TEST DOCUMENTATION:
Standard Test Procedures
Detailed Operating Procedures
Detailed Maintenance Procedures
Components Breakdown and Parts List

TEST EQUIPMENT

A current list of equipment and parts to be provided to other Naval facilities has already been established. The major components to be standardized throughout the Navy are shown in table 1 and described in figures 7 and 8. However, it is not the intention of the Naval Air Warfare Center at Patuxent River to be the sole provider of this equipment. An illustrated parts list, assembly instructions, and operational procedures will be provided at no cost to any facility wishing to fabricate their own test set. All parts will be listed with detailed diagrams showing design

HIGH VOLTAGE GENERATOR SPECIFICATIONS:

	AN/L CASING:	RACK MOUNT:
UNIT HEIGHT	29 in (737 mm)	12 in (305 mm)
UNIT WIDTH	24 in (610 mm)	19 in (480 mm)
UNIT DEPTH	24 in (610 mm)	15 in (381 mm)
WEIGHT	94 lb (64 kg)	

POWER SUPPLY:
120 V 60/80 Hz SINGLE PHASE
[OPTION: 220 V 50/60 Hz SINGLE PHASE]

POWER OUTPUT	80 W
MAX VOLTAGE OUTPUT	40 kV
MAX CURRENT OUTPUT	2 mA
REGULATION	10% NL-FL
RIPPLE	2% rms

VOLTMETER (DC kV)		AMMETER (DC mA)	
LOW	0 - 8	LOW	0 - 0.4
MID	0 - 20	MID	0 - 0.8
HIGH	0 - 40	HIGH	0 - 2.0

ACCURACY ±2% FULL SCALE

HIGH VOLTAGE WAND SPECIFICATIONS:

AMMETER	100 - 0 - 100 µA DC
HIGH VOLTAGE CABLE	12 AWG 80 kV
DISCHARGERS	QTY. 8 DD 15340 SPEC.

MULTI-BAND RECEIVER SPECIFICATIONS:

QTY.	2
NUMBER RX BANDS	4
POWER	6 VDC

RX RANGES:

FSS	144 - 174 MHz
AIR	108 - 136 MHz
FM	76 - 108 MHz
AM	150 - 2184 kHz (LW/MW/SW)

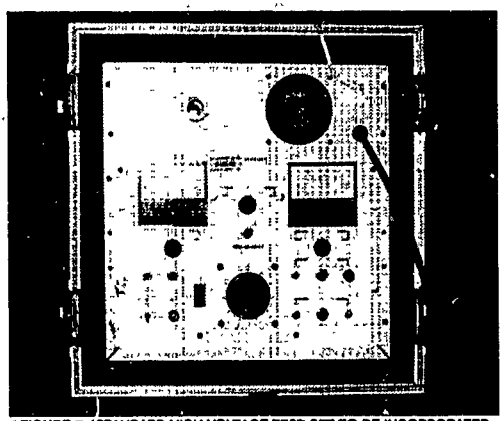

FIGURE 7. STANDARD HIGH VOLTAGE TEST SET TO BE INCORPORATED THROUGHOUT THE NAVY

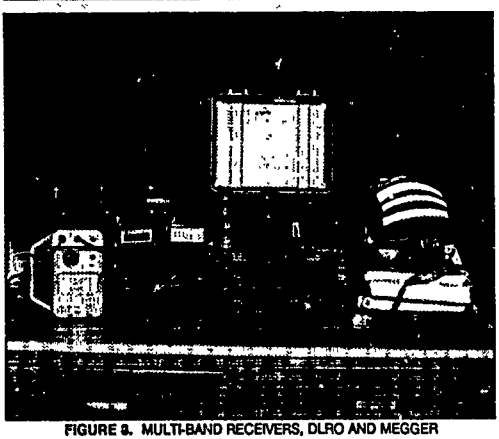

FIGURE 8. MULTI-BAND RECEIVERS, DLRO AND MEGGER

DIGITAL LOW RESISTANCE OHMMETER SPECIFICATIONS:

UNIT HEIGHT	6.4 in (162 mm)
UNIT WIDTH	12 in (305 mm)
UNIT DEPTH	9.8 in (248 mm)
WEIGHT	12.1 lb (5.5 kg)

RESISTANCE MEASUREMENT RANGES:

0.000	-	5.999	mΩ	1 µΩ RES.
00.00	-	59.99	mΩ	10 µΩ
000.0	-	599.9	mΩ	100 µΩ
0.000	-	5.999	Ω	1 mΩ
00.00	-	59.99	Ω	10 mΩ

POWER REQUIREMENTS:

0.220 A / 115 V, 50/60 Hz or
0.185 A / 230 V, 50/60 Hz

DIGITAL MEGOHMMETER SPECIFICATIONS:

UNIT HEIGHT	4.2 in (107 mm)
UNIT WIDTH	4.5 in (114 mm)
UNIT DEPTH	7.0 in (178 mm)
WEIGHT	1.9 lb (0.86 kg)

MEASUREMENT RANGES:

0	-	2000	MΩ	@ 1000 V
0	-	2000	kΩ	@ 500 V
0	-	600	VAC	

600 V AC MAX INPUT
1000 V DC MAX OUTPUT
POWER 9 VDC

specifications, how to fix damaged components and parts, and where to procure new ones. In this way, it will be possible for any Naval facility to provide maintenance and upkeep of the P-Static test equipment without having to constantly send equipment back to the manufacturer.

This is by no means the only equipment possible for P-Static ground testing of aircraft. The EMP section at Patuxent River also utilizes various forms of instrumentation for P-Static testing to determine the extent of interference found on the aircraft equipments (see figure 9).

The purpose of providing standard test methods and equipment is to make P-Static testing of Navy aircraft simpler, more cost-effective, and decentralized, while also enhancing the Navy's current P-Stating testing capabilities.

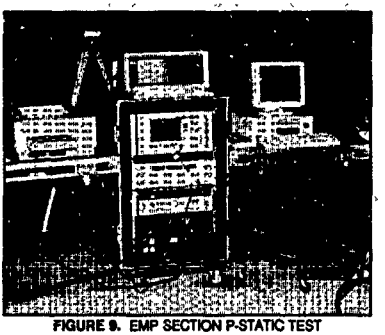

FIGURE 9. EMP SECTION P-STATIC TEST INSTRUMENTATION

DISTRIBUTION PLANS

Currently, the Naval Air Warfare Center at Patuxent River has plans to distribute five of these P-Static equipment and documentation packages to the Naval Depots located in Alameda, Jacksonville, Norfolk, North Island, and Pensacola. The sixth Naval Depot, located in Cherry Point, North Carolina, has already received this equipment with operating procedures, and has been involved in P-Static testing since October 1990.

This will give these facilities the ability to provide P-Static maintenance support for aircraft undergoing modification/ retrofits on location. Because these facilities are involved in all production and maintenance revolutions of Naval aircraft, they are prime candidates for standardizing P-Static testing capability.

A six month program has been set up by the Naval Air Warfare Center at Patuxent River to manufacture and distribute these five sets of P-Static equipment and documentation. Also, other facilities are currently being coordinated with, to provide further P-Static testing capability throughout the Navy. This will create a larger user base of P-Static testing facilities, as well as assure awareness of P-Static and the effects of interference and shock hazard problems it causes on aircraft.

SUMMARY

By incorporating standard test methods and equipment throughout the Navy, a reliable system of Precipitation Static ground testing of aircraft can be established. It will provide a relatively simple and cost-effective means of testing aircraft and systems for P-Static effects while still in the production and manufacturing phases. Also, the need for a large test program to get aircraft certified to operate under P-Static weather conditions will be greatly reduced.

By distributing widely accepted methods of P-Static testing, problems will

be minimized if a facility decides to use different P-Static testing equipment, and will also make standard procedures for testing aircraft available to all Naval facilities. Equipment design specifications will also be available to Naval facilities, allowing on-site repair and replacement capability.

By distributing these test methods and equipment to the six Naval Depots currently existing, a strong capability for P-Static testing, development, and awareness will exist for all Naval aircraft programs.

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1. MIL-STD-5087B, Bonding, Electrical and Lightning Protection for Aerospace Systems, 2 September 1967.
2. MIL-STD-9129D, Electrostatic General Specification for Military Specification Dischargers, 30 September 1986.

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PRESENTED BY

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AIRCRAFT DIVISION
FLIGHT TEST ENGINEERING GROUP
PATUXENT RIVER, MD

OVERVIEW

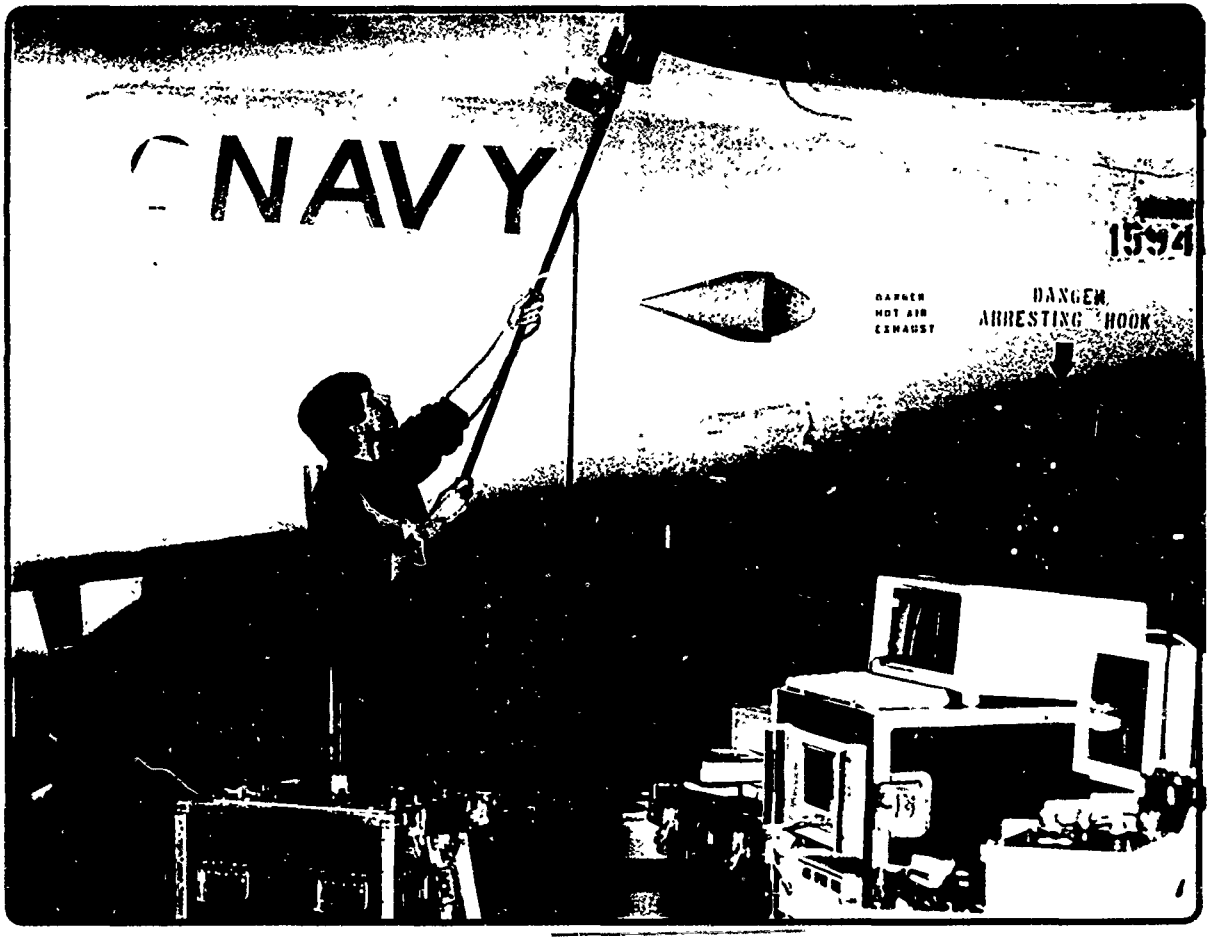
- INTRODUCTION
- TEST METHODOLOGY
- TEST EQUIPMENT
- TEST DOCUMENTATION
- DISTRIBUTION PLANS
- SUMMARY

INTRODUCTION

- RESPONSIBLE ORGANIZATION
- HISTORY
- DISTRIBUTION PROGRAM

TEST METHODOLOGY

- P-STATIC TEST EQUIPMENT
- EMI TESTING OF AIRCRAFT
  - PASSIVE SYSTEMS
  - ACTIVE SYSTEMS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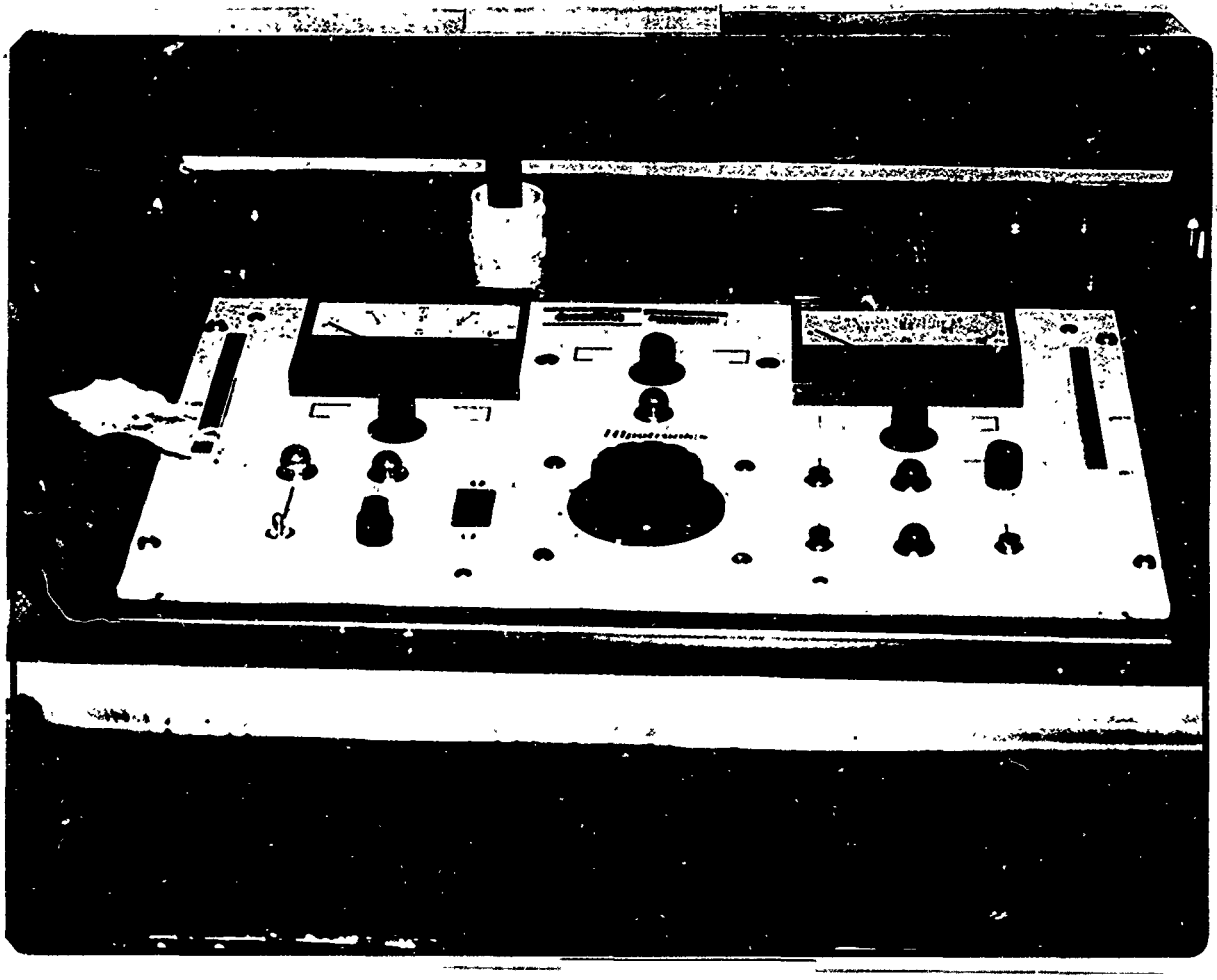

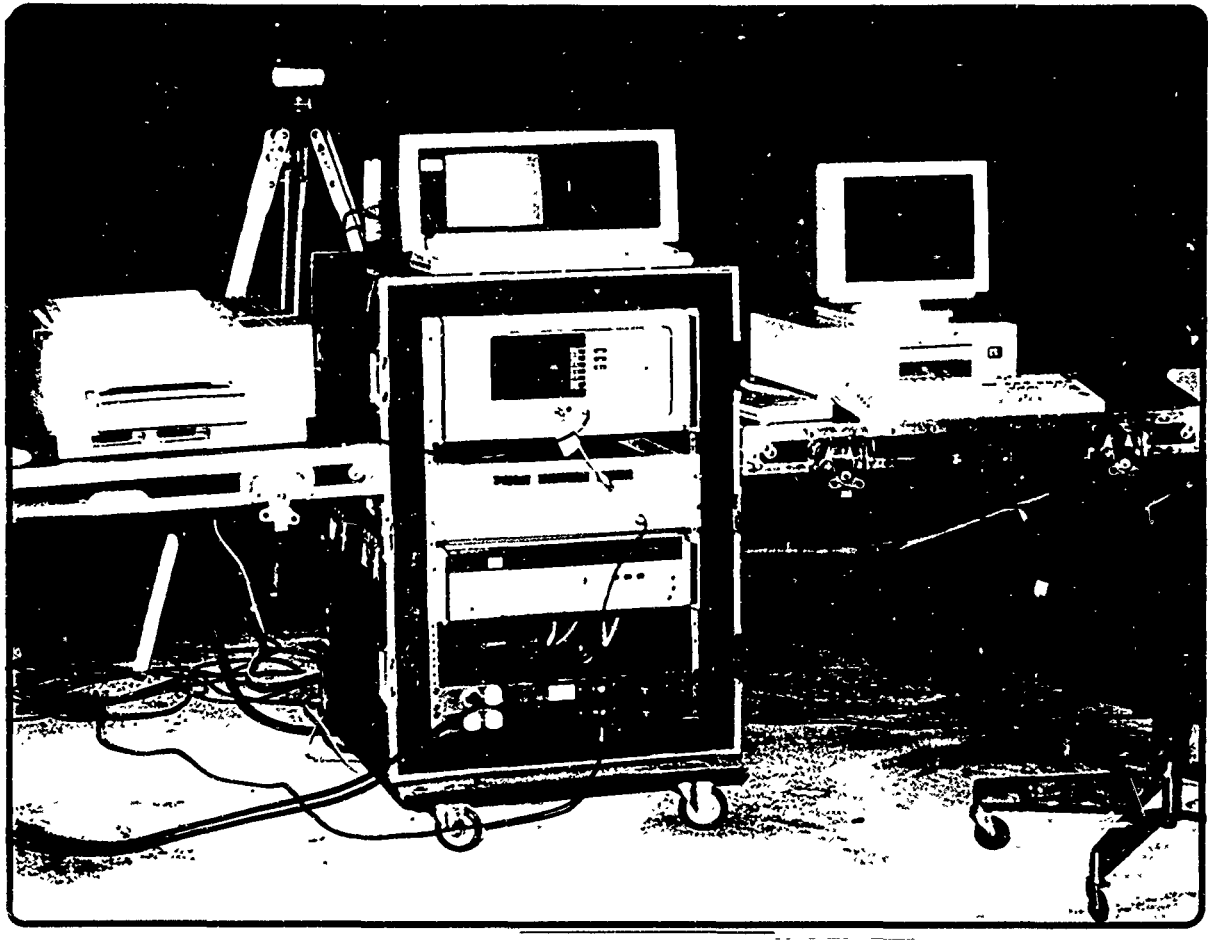

TEST METHODOLOGY
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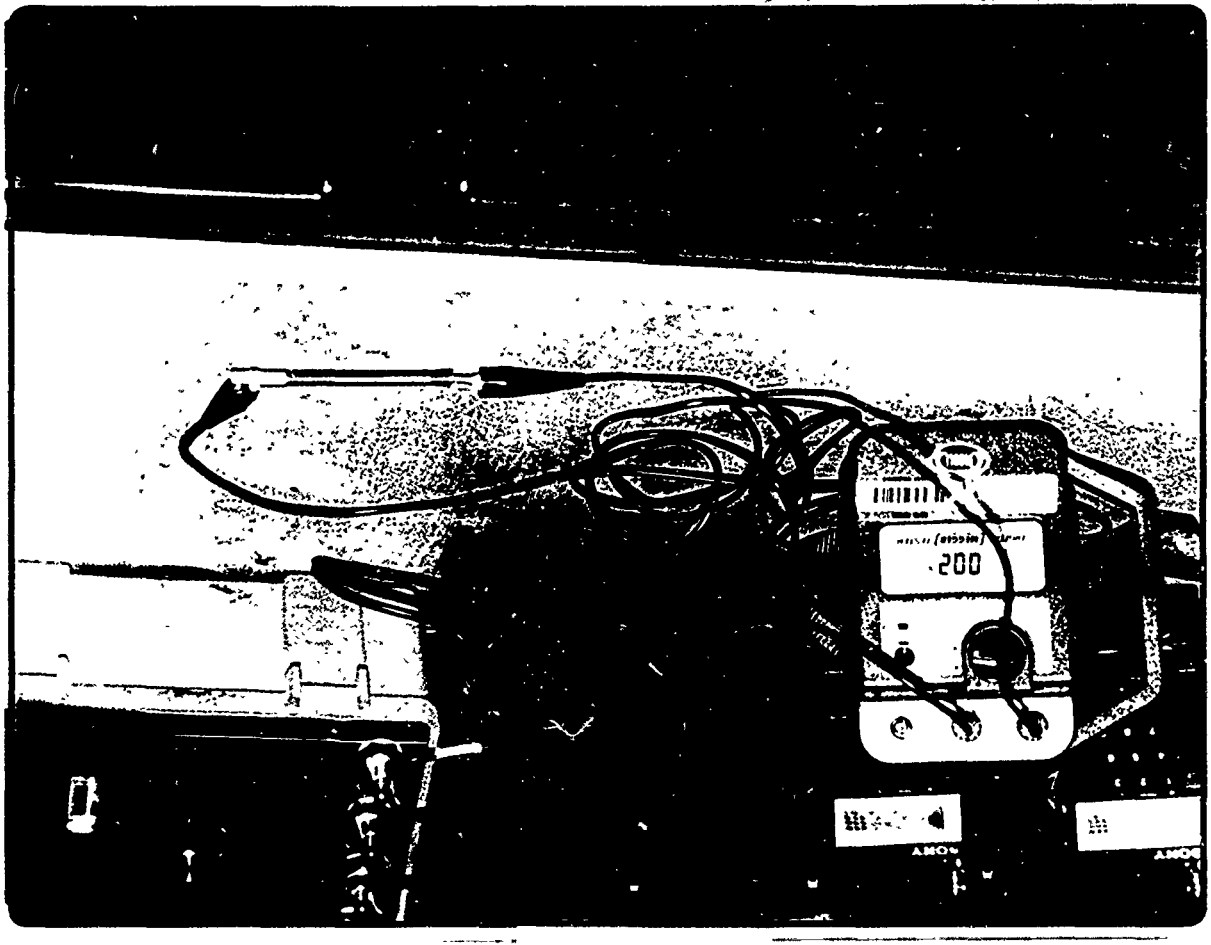
- HIGH VOLTAGE TESTING OF STATIC DISCHARGERS
- RESISTANCE AND BONDING MEASUREMENTS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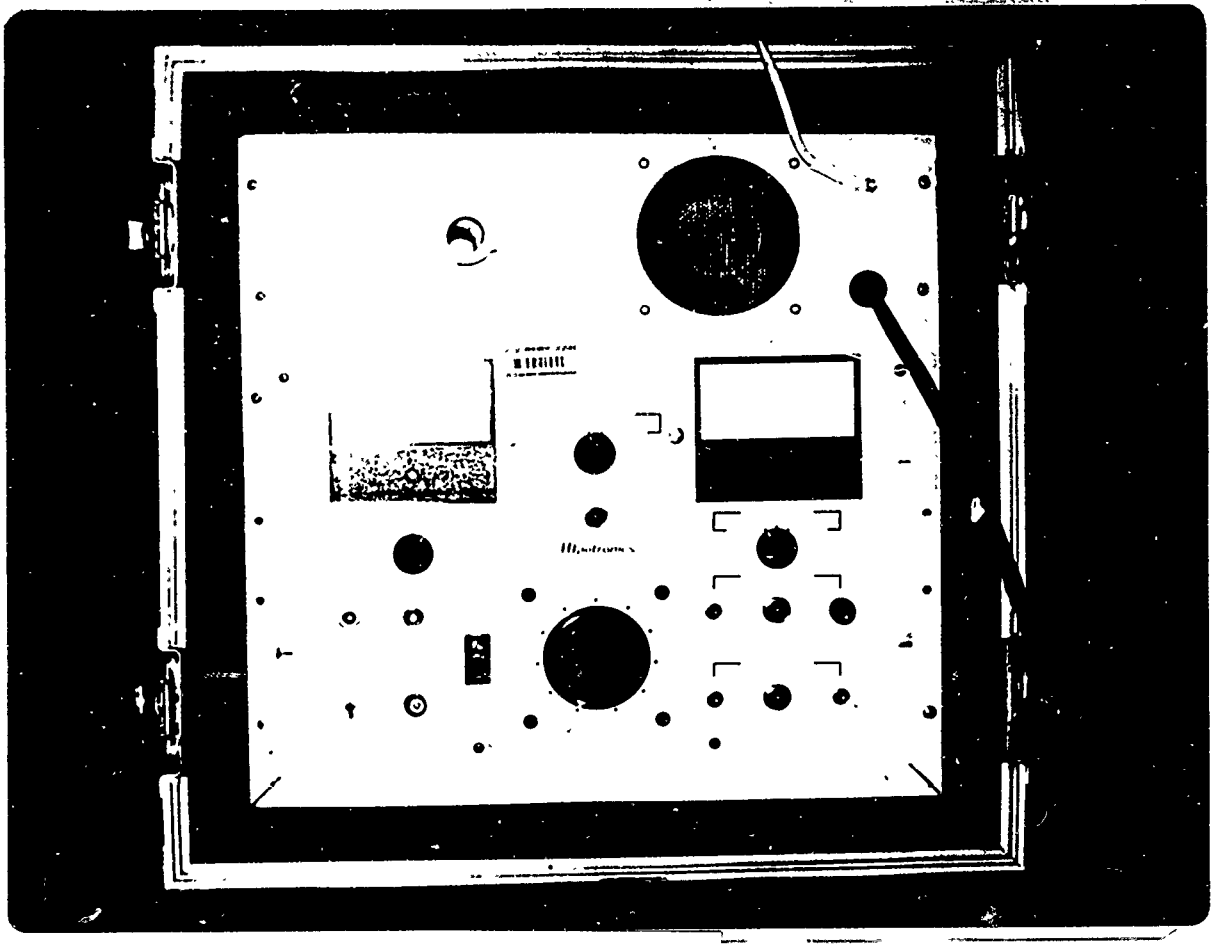
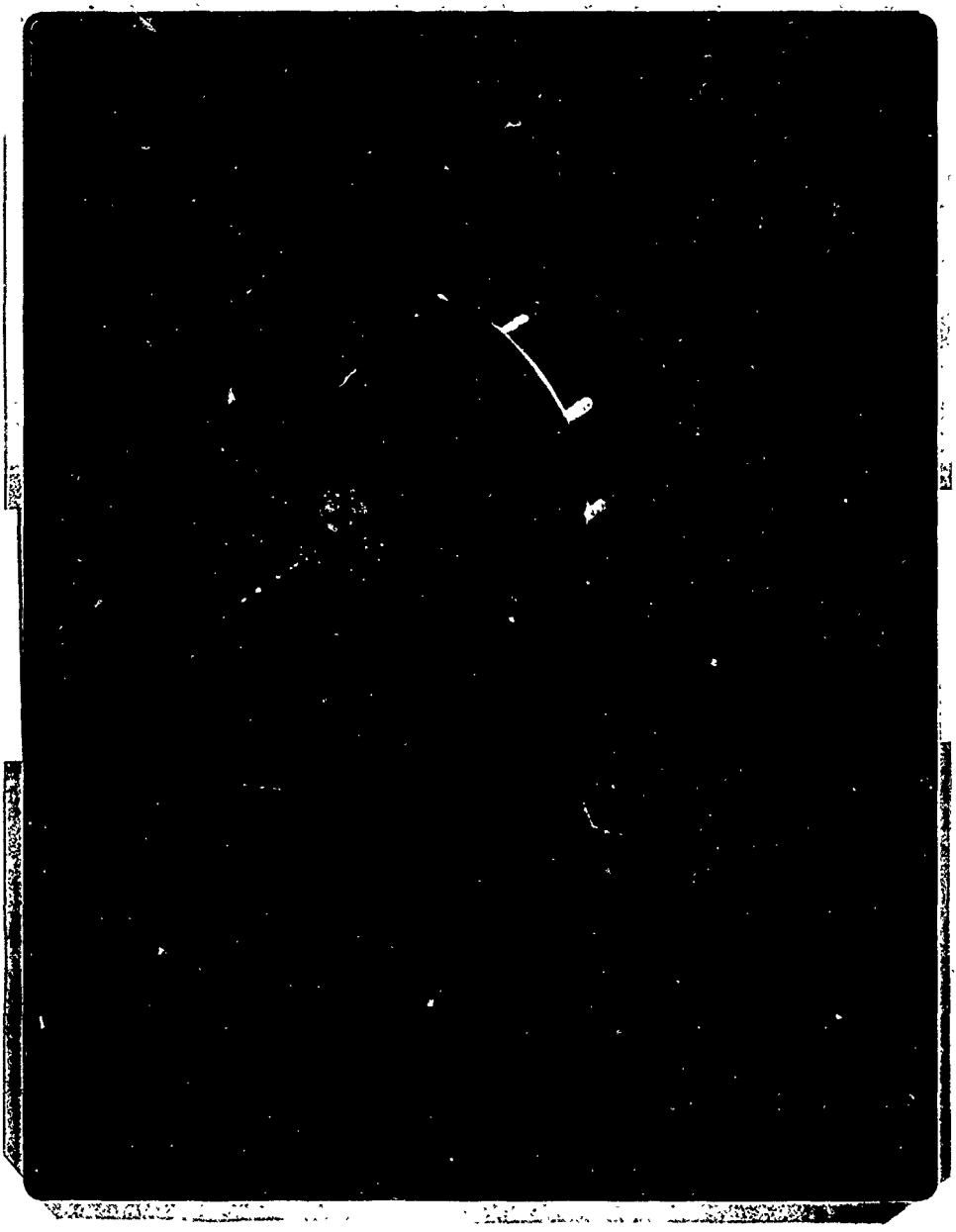
TEST EQUIPMENT

- HIGH VOLTAGE POWER SUPPLY
- HIGH VOLTAGE DISCHARGE WAND
- DIGITAL LOW RESISTANCE OHMMETER
- DIGITAL MEGOHMMETER
- HAND-HELD MULTIBAND RECEIVERS
- ANVIL CARRYING CASES





TEST DOCUMENTATION

- STANDARD TEST PROCEDURES
- DETAILED OPERATING PROCEDURES
- DETAILED MAINTENANCE PROCEDURES
- COMPONENTS BREAKDOWN AND PARTS LIST

DISTRIBUTION PLANS

- **DISTRIBUTED TO SIX NAVAL DEPOTS:**
  - NAS CHERRY POINT, NORTH CAROLINA
  - NAS ALAMEDA, CALIFORNIA
  - NAS JACKSONVILLE, FLORIDA
  - NAS NORFOLK, VIRGINIA
  - NAS NORTH ISLAND, CALIFORNIA
  - NAS PENSACOLA, FLORIDA

SUMMARY

- STANDARD TEST METHODS AND EQUIPMENT
- COST EFFECTIVE
- AIRCRAFT CERTIFICATION DECENTRALIZED
- INCREASED NAVY P-STATIC TEST CAPABILITY
- INCREASED AWARENESS